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30 April 1964

BELLCOMM, INC.

QUARTERLY PROGRESS REPORT

JANUARY FEBRUARY MARCH

1964

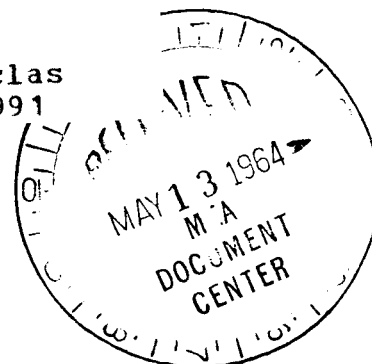


(NASA-CR-116528) QUARTERLY PROGRESS REPORT,
JANUARY MARCH 1964 (Bellcomm, Inc.) 25 p

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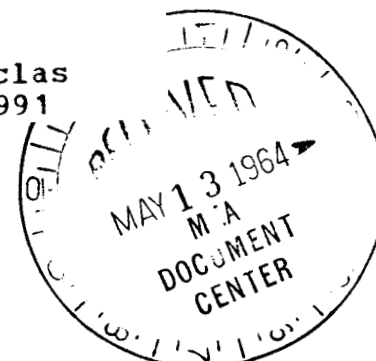
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Report No. 64-101-2
Contract NASw-417
30 April 1964

NASA APOLLO PROGRESS REPORT

BELLCOMM, INC.

QUARTERLY PROGRESS REPORT

JANUARY FEBRUARY MARCH

1964

J. A. Hornbeck
President

BELLCOMM, INC.

Washington, D. C.

Report No. 64-101-2
Contract NASw-417

QUARTERLY PROGRESS REPORT

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BELLCOMM, INC.

Report No. 64-101-2
Contract NASw-417

ABSTRACT

The activities of Bellcomm, Inc., during the quarter ending March 31, 1964, are summarized. Reference is made to reports issued during this period covering individual technical studies.

BELLCOMM, INC.

BELLCOMM, INC.
QUARTERLY PROGRESS REPORT

JANUARY FEBRUARY MARCH
1964

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BELLCOMM, INC.

General Systems Engineering

Significant activities which are preliminary to definitions of task order studies are included in the following summary of general systems engineering efforts.

- A. The study of suborbital aborts for a Saturn V Apollo mission has continued. Two abort modes that are included in the present phase of the study are as follows:

1. Direct entry into the atmosphere after the trajectory of the Command Module has been altered by the S-IVB or Service Module propulsion.
2. Continuation into a parking orbit using either the S-IVB or Service Module propulsion system.

A report is now in preparation.

- B. Work is continuing at Bell Telephone Laboratories on a tracking capability analysis. A report ⁽¹⁾ covering the computer program and analysis for the earth orbital phase of the Apollo Lunar Mission has been completed.
- C. A report on work-rest cycles, habitability and confinement of the astronaut during space flight missions has been completed and distributed in NASA ⁽²⁾. This report summarizes the relationship between the above factors and human performance and discusses the extent to which these factors will influence crew performances during space missions.
- D. During this quarter a wall display was developed covering the Saturn/Apollo major milestones of design, manufacturing, ground test and flight test events. Certain constraints on the flight test program are indicated. The display reflects status changes against a selected base line (MSF Flight Schedules and Status Review, February 1964). Also depicted are important interactions with other programs which support Apollo, such as Surveyor, Orbiter and IMP. This display is intended to provide the technical staff with a description of major milestones and their time phasing.
- E. A study is in progress to determine the relationship between the accuracy of spacecraft orbit determination and the accuracy of lunar landmark location. Accuracies with which the flight conditions at periselene of the

(1) Memorandum for File - Apollo Communication and Tracking System Performance During Earth Parking Orbit Phase, R. W. Priester and J. O. Replogle, Bell Telephone Laboratories, February 17, 1964.

(2) The Relationships of Work-Rest Schedules, Confinement and Habitability to Crew Performance as Anticipated for Space Missions, B. H. Crane, January 31, 1964.

Hohmann descent orbit can be statistically predicted have been analyzed for a number of different navigational profiles. Navigation is assumed to be performed by making angular measurements by a theodolite on board the spacecraft against landmarks on the lunar surface. The problem was treated in a coordinate system that is centered in the lunar landing site. Preliminary assessment of the results indicate that the navigational accuracy achievable with realistic landmark accuracies are entirely adequate for Apollo, especially if the landing site is used as a navigational fix.

- F. Work has been continued on the systems aspects of lunar landing dynamics studies being carried out in NASA and industry. As a result of this effort, a need was established for further investigation of landing dynamics phenomena not currently under study. Requests for proposals for a landing dynamics systems study were released to two companies in January 1964 and replies were received in February. After evaluation a subcontract was awarded to Bendix Products Aerospace Division, South Bend, Indiana, effective March 16, 1964. Coordination of landing dynamics studies with LRC, MSFC and MSC have continued. Joint efforts with MSC are in progress to evaluate the capability of the current LEM landing gear design.
- G. A preliminary NASA document prepared by the MSF Directorate of Space Medicine and entitled "Human Standards for Project Apollo" was reviewed and a memorandum (3) summarizing this review was prepared. This memorandum contains recommendations for additional work in this area.
- H. At the request of NASA a briefing on MILA preflight operations was prepared and presented to the Deputy Director of the Apollo Program.
- I. Factors which have led to proposals for development of a cryogenic Service Module for Apollo have been studied. A technical evaluation (4) of some of the program alternatives suggests that programs to increase launch vehicle payload capability would be preferable to development of a cryogenic Service Module.
- J. Activity related to control weights and vehicle payload capabilities continued during this reporting period with emphasis placed on the requirements for Apollo Flight Test Missions.

(3) Review of Human Standards for Project Apollo, T. A. Bottomley, E. M. Coombs, P. R. Knaff, T. S. Luce, M. M. Purdy and S. J. Schoen, March 6, 1964.

(4) Cryogenic Stage for the Apollo Spacecraft (Confidential) TM-64-2111-1 M. W. Cardullo, March 16, 1964.

TASK ORDER NO. 1

ASSIST NASA IN THE PREPARATION OF A MASTER PLAN FOR THE MANNED SPACE FLIGHT PROGRAM.

Throughout the quarter, work continued on revisions and additions to the Apollo System Specification M-DM 8000.001.

Revisions to Sections 4.4, 4.5 and 4.8 dated February 1, 1964 covering respectively; Navigation, Guidance and Control, Space Vehicle Communications and Ground Communications and Tracking were approved by the Deputy Director, Apollo Program on March 3, 1964. Supplements incorporating these changes were distributed to all recipients of the Apollo System Specification.

At the request of the Associate Administrator - Manned Space Flight, a draft ⁽⁵⁾ of an abbreviated Apollo System description was prepared and transmitted to the Deputy Director - Apollo Program for comment.

Effort has continued on a study defining the inflight checkout requirements. A discussion on preliminary system requirements was held with MSC in January.

(5) An Apollo System Description (draft), J. J. Fitzpatrick, J. M. Llewellyn, Jr., February 4, 1964.

TASK ORDER NO. 9

ANALYSIS, DATA COLLECTION AND TECHNICAL COORDINATION REQUIRED
TO PROVIDE DEVELOPMENT OF REFERENCE TRAJECTORIES FOR THE
APOLLO LOR MISSION.

Considerable additional work has been done during this quarter to define the ΔV budget for the Apollo space vehicle. Steps are now being taken to incorporate the ΔV budget in the Apollo System Specification.

A survey report on the potential abort trajectories for Apollo is in preparation. A major part of the trajectory effort during this quarter has been directed toward this report.

The placing of additional work with Space Technology Laboratories is currently in process and work has begun, on a temporary funding basis, on the reference trajectories for the Apollo System Specification. Two of a six volume set of reports have been received from the Space Technology Laboratories. These documents ⁽⁶⁾ cover comparison of ground based and onboard orbit determination accuracies.

(6) Analysis of Apollo Orbit Determination Accuracy with Random Errors in
Ground Based Radar and Onboard Optical Observations, Space Technology
Laboratories.

Volume 2, The Earth Parking Orbit, January 20, 1964
Volume 4, The Lunar Parking Orbit, February 24, 1964

TASK ORDER NO. 10

ASSIST THE OFFICE OF SYSTEMS IN DEVELOPING A CHECKOUT PROGRAM.

The joint MSFC-Bellcomm Checkout Study has continued. This study presents both short and long range proposals as follows:

1. Short Range - Study of means for using the LCC computer to back up the LUT computer in all functions normally performed by the LUT computer after propellant loading has been started. This has resulted in:
 - a. A definition of the requirements for the switching networks needed to switch to the back up mode. An interim report was presented to MSFC in March 1964 and a formal report is in preparation.
 - b. A partial definition of the equipment on the LUT required for the back up mode.
 - c. A study proposal for alternative hardware configurations.
2. Long Range - In addition to availability requirements, a countdown control system must meet another basic requirement: the protection of the flight system from harmful effects of executing erroneous critical commands. Possible methods for meeting both requirements in a redundant system have been studied. A specific hardware configuration for meeting both requirements has been proposed together with some operating strategies (7).

The study requested by NASA on the use of relays vs. semiconductors in the Apollo spacecraft switching functions was completed in January. A report was submitted to MSC summarizing the criteria for either application.

Additional reliability studies were conducted in the area of relays vs. semiconductors. (8) Specifically, an analytical study was made on the reliability of a number of redundant repairable systems (9) (10).

-
- (7) Proposed Redundant Launch Control and Checkout System, C. A. Lovell and W. H. Wattenburg, March 4, 1964.
 - (8) The Use of Relays vs. Semiconductors in Apollo Switching Applications, T. I. Barrett-Smith, January 16, 1964.
 - (9) The Reliability of some Simple Redundant Repairable Systems, I. D. Nehama, January 28, 1964.
 - (10) Reliable Considerations for Systems with Constant Repair Times, B. H. Liebowitz, January 30, 1964.

A two months study of programming requirements for the digital computer-based systems in Apollo has been completed. This study established the following:

- A. That the total effort i. e., manpower, facilities required for the preparation, testing and verification of these computer programs will involve large government expenditures (> \$100 million).
- B. That insufficient formal NASA procedures exist for the planning for: procurement, testing, documentation, procurement control, validation, and acceptance of contractor-produced computer programs. Bellcomm has been requested by NASA to undertake a task to study and recommend steps to improve this situation.

TASK ORDER NO. 11

CARRY OUT STUDY LEADING TO AN EVALUATION OF THE NATURAL ENVIRONMENTAL FACTORS IMPORTANT TO THE SUCCESSFUL PERFORMANCE OF THE MANNED SPACE FLIGHT PROGRAM.

During this quarter Bellcomm completed and distributed copies of the following reports within NASA:

A detailed analysis (11) of the effect of the meteoric infall on the lunar surface which indicated extensive small scale cratering.

A revision (12) of the meteoroid environment report which discussed the data obtained by Explorer XVI and included this data in a new environmental model.

An assessment (13) of the soil mechanics problems on the lunar surface which pointed out considerable uncertainties in earth-based experimentation and emphasized the corresponding importance of in situ experiments by the unmanned lunar program.

A report (14) which discussed constraints on the number and location of Apollo landing sites on the lunar surface and included environmental, operational and spacecraft considerations.

An analysis (15) which discussed the status of programs to measure solar flare cosmic rays.

A report (16) which selected a group of models concerning radiation in the space environment.

-
- (11) Meteoric Infall and Lunar Surface Roughness, G. T. Orrok, January 31, 1964.
- (12) The Meteoroid Environment of Project Apollo - Edition II, G. T. Orrok, January 31, 1964.
- (13) Lunar Soil Mechanics, N. W. Hinnners, January 13, 1964.
- (14) Lunar Landing Site Constraints, W. B. Thompson, January 31, 1964.
- (15) Status of Programs to Measure Solar Cosmic Rays, E. N. Shipley, January 31, 1964.
- (16) Models for Space Environmental Hazards: Radiation-Issue II, H. J. Shulte, E. N. Shipley, January 31, 1964.

Two studies (17) (18) relating to Bellcomm activities in monitoring the Jet Propulsion Laboratory study of instrumentation for Follow On Surveyors. Copies of these reports were forwarded to JPL for their information.

A report (19) summarizing Task 11 to January 31, 1964, was delivered along with the eight other above-noted reports covering particular topics. Further work of this nature is being undertaken under an amendment to this task order.

Studies concerning the structural and photometric properties of the lunar surface have continued and several meetings have taken place with NASA representatives to discuss these problems.

Issue III of "Requirements for Data in Support of Project Apollo" was prepared by Bellcomm and transmitted by the Associate Administrator of MSF to SSA and ART. Discussions with SSA and ART concerning this document have taken place.

Work has continued on necessary technical revisions to the MSF Program Directorate "Natural Environmental and Physical Standards for Project Apollo". Related work has been carried out on the preparation of an environmental appendix for the "Apollo System Specification".

Radiation shielding studies have proceeded with the design of computer programs capable of calculating radiation doses at various depths in tissue, behind a given shield thickness and with a given distribution in rigidity of the input particles. With this program a study of the Apollo mission with respect to radiation hazards is underway.

A critique of a six-month Space General Corporation Study of landing probes for an Apollo Mapping and Survey System was made and the results were transmitted informally to the Advanced Manned Mission Directorate in MSF.

Studies of the Lunar Orbiter have continued with particular attention being placed on the strategy of its use in Apollo site certification.

During this quarter we have continued to act as consultants to the Space Sciences and Applications Directorate for their studies of a Surveyor Lunar Roving Vehicle.

(17) Surveyor Site Certification Study, H. W. Radin, January 31, 1964.

(18) An Analysis of Lunar Site Certification by the Unmanned Program, C. J. Byrne, R. F. Fudali, M. A. Leibowitz, T. L. Powers, January 31, 1964.

(19) Summary of Work Performed Under Bellcomm/NASA Task Order No. 11, B. T. Howard, D. B. James, January 31, 1964.

TASK ORDER NO. 12

ASSISTANCE IN CERTAIN COMPUTER OPERATIONS AND RELATED ACTIVITIES

This task was initiated between NASA and Bellcomm in October, 1963 to render assistance to NASA with respect to the performance of computations involving the use of the IBM 7044 computer and its associated peripheral equipment.

During this quarter NASA use of the computing facilities amounted to approximately 6 hours.

TASK ORDER NO. 13

APOLLO FLIGHT TEST PLAN

Task Order No. 13 was completed on January 31, 1964 with the transmission of draft material to MSF. Certain follow-on activity has been provided for in new Task Order No. 17 entitled "Apollo Flight Mission Assignments", which will extend through September 30, 1964.

TASK ORDER NO. 14

APOLLO OPERATIONS PLANNING

Development of a Mission Sequence Plan continued with the objective of generating functional criteria for equipment design, measuring the adequacy of current Apollo hardware for operational needs and providing a basis for more detailed mission planning. A preliminary plan (20) was completed January 31, 1964 and distributed to cognizant personnel at NASA Centers for their use and review. The preliminary plan has also been reviewed with the Grumman "Apollo Mission Planning Task Force".

(20) Preliminary Skeletal Operations Plan for Apollo - A Systems Engineering Support Document, Bellcomm Operations Planning Group with assistance from Bell Telephone Laboratories, Inc., January 31, 1964.

TASK ORDER NO. 15

FORMULATION OF SYSTEM REQUIREMENTS FOR, AND EVALUATION OF
COMMUNICATION FACILITIES TO BE USED FOR APOLLO FLIGHT MISSIONS.

A report was prepared and distributed on the tracking and communication coverage that could be provided during the reentry and pre-reentry phases of the lunar landing mission. Several choices of landing sites were considered and it was concluded that complete reentry coverage could be provided at all times by three tracking ships on all days of the lunar month and a large percentage of coverage could be provided by two tracking ships. It was also determined that, for landing areas in the mid-Pacific, five or more minutes of coverage could be provided on all return trajectories after the staging of the Service Module at 30 minutes prior to reentry (400,000 ft. altitude) with tracking and communication sites at Madrid, Canberra, Goldstone, Carnarvon and Guam. (21)

During this quarter, Bellcomm personnel assisted MSC (ASPO) personnel in preparing the first draft of a Level II specification of Apollo communication and tracking equipment.

An analysis was made to determine the advantages and disadvantages to be obtained in locating the big (85 ft. diameter) MSFN S-band tracking and communication antenna at sites other than at the locations of the DSIF antennas as is currently planned. It was concluded that there are strong technical and economical advantages in not collocating these equipments. A report on this study is being prepared.

The analysis of the tracking and communication coverage that can be provided for the early developmental flights of the Apollo vehicles is continuing. Computer programs have been completed that permit a determination of the coverage provided by as many as 40 sites. A separate computer program has been devised that includes the effects of space vehicle antenna patterns.

The reentry communication problem is being analyzed and a report will be issued on the current state of knowledge of reentry blackout phenomena.

The investigation is continuing of methods of processing radar data at remote tracking sites to minimize the amount of data required to be transmitted to the IMCC. Two additional memoranda on this subject were published. (22), (23)

(21) Communication and Tracking Coverage for the Reentry Phase of Apollo Lunar Missions, Bell Telephone Laboratories, Inc., March 10, 1964.

(22) Single-Pass Orbit Determination by Smoothing Radar Orbital Tracking Data, G. H. Myers, Bell Telephone Laboratories, February 27, 1964.

(23) Preprocessing Data at Apollo Tracking Sites, G. H. Myers, Bell Telephone Laboratories, March 19, 1964.

Work was initiated on an analysis to determine the utility of satellite communication between remote sites, ships, and aircraft and the Manned Space Flight Network.

Studies under this task resulted in a revision of the communications section of the Apollo System Specification.

TASK ORDER NO. 16

MISCELLANEOUS SHORT-RUN STUDIES AND EFFORTS OF IMMEDIACY

- 16-1 - LEM Guidance and Navigation System Validation Study. Activity on this study during the quarter included a simulation of guidance and navigation system performance during lunar landing; examination of the capabilities of guidance computers and strapped-down inertial measurement units, and consideration of lunar ascent and abort. A report covering the effort is in preparation.
- 16-2 - Instrumentation Ship Requirements for Apollo. At the beginning of this quarter, a review of the status of the Instrumentation Ship Requirements for Apollo indicated that it was unlikely that Bellcomm would be asked to study this problem further. All the work that was done on the Instrumentation Ship Requirements for Apollo was done in the third quarter of 1963 and has already been reported. Since no work had been performed and no work was contemplated, Task 16-2 was closed out on January 21, 1964.
- 16-3 - Environmental Control Systems for Apollo. A review of Environmental Control Systems for Apollo (24) was conducted to assess the status of current and potential problem areas. Technical recommendations were made to MSC in six primary problem areas. Secondary and potential problem areas to be watched were discussed.
- 16-4 - Command Module Programmer for Unmanned Missions. Since mid-February, 1964, Bellcomm has provided assistance to the Apollo Spacecraft Project Office (MSC) in determining basic requirements and development guide lines for a programmer for unmanned Apollo flight test missions. Modifications to the input/output circuitry of the Apollo Guidance Computer (AGC) that would be necessary in order to use the AGC as the prime mission sequencer were considered. Also, the AGC memory available for mission sequencing programs and the time during which the AGC would be available for executing such programs were examined. Use of the AGC to perform both the mission sequencing functions and the normal guidance functions appears feasible. Continuing effort will include a review of abort options and their effects on the complexity of the sequencing equipment needed to back up the AGC.
- 16-5 - Review of Meteoroidal Hazards to Apollo. A review of the meteoroid hazard to spacecraft is approaching completion. The objectives of the study are to summarize the uncertainties, to estimate any degree of

(24) Review of Environmental Control Systems for Apollo, T. A. Bottomley, R. A. Kaenel, P. R. Knaff, R. W. Sears, J. E. Waldo, (Confidential), February 10, 1964

conservatism or liberalism in the models, and to suggest action both in spacecraft design and in programs to reduce the uncertainty.

Visits were made to North American Aviation and Grumman to discuss the results of their studies of environmental factors, and to obtain up-to-date information on spacecraft configurations. Experts on hyper-velocity impact were consulted at Ames Research Center and at General Motors Defense Research Laboratory. An improved description of meteoroid bumpers is being developed. Finally, several visits have been made to Houston for the purpose of integrating these studies with the reviews currently in progress at MSC.

- 16-6 - Launch Vehicle Propellant Loading System. The work on this case comprises studies of the propellant loading system for Saturn V. Bellcomm is assisting KSC-KD in reviewing the plans for the loading of the fuel and oxidant tanks of the Saturn V vehicle to determine whether acceptable accuracy can be obtained with a simpler system than the presently planned Digital Propellant Loading Control System.

These studies include considerations of the accuracies and noise of the mass sensor outputs from the tanks, the dynamics of the cryogenic replenish and topping systems, and the loads on the central digital computer system.

TASK ORDER NO. 17

APOLLO FLIGHT MISSION ASSIGNMENTS

Work at Bellcomm and with MSC and MSFC during this quarter, including the January effort under Task 13, resulted in the definition of several types of flight missions for the Saturn IB and Saturn V Programs. This effort included the examination of test objectives, profiles, payload requirements, and flight hardware configurations to verify gross feasibility of each mission type.

A flight mission assignment plan, which integrates these mission types with current Saturn IB/Saturn V launch schedules and Apollo spacecraft availability data, was developed and reviewed with the NASA Centers. The plan provides flexibility to accommodate contingency flight requirements.

The Saturn IB/Saturn V flight mission assignments plan and the associated Little Joe II and Saturn I flight assignments were approved by MSF and published (25).

Continuing effort will include further definition of the Saturn IB/Saturn V mission types.

(25) Apollo Flight Mission Assignments M-DE-8000.005B, March 23, 1964.
(Confidential)

TASK ORDER NO. 18

PLANNING OF SYSTEMS OPERATIONS AND EXPLORATION TASKS - FIRST PHASE MANNED LUNAR EXPLORATION

This task became effective on March 17, 1964. Activities to date have consisted of information gathering and liaison with the Advanced Manned Missions Directorate of MSF.

Preliminary studies of the scientific tasks to be performed on the lunar surface were carried out to obtain background information and to allow interpretation of the scientific guidelines for the Apollo missions. A technical memorandum ⁽²⁶⁾ has been issued on this subject.

(26) Initial Lunar Scientific Studies by Apollo Astronauts, TM 64-1111-1
N. W. Hinners, dated March 4, 1964.

COMPUTING FACILITY

As of March 31, 1964, all of the major items of equipment listed below have been delivered and installed at Bellcomm.

- 1 - 7044 Computer with 32K words of core storage
- 12 - 729 Magnetic Tape Units
- 1 - 1401 Peripheral Processor
- 2 - 1403 High Speed Printers
- 2 - 1402 High Speed Card read/punch
- 1 - 1301 Disk Storage Device
- 1 - 7040 Computer with 32K words of core storage

The above items of equipment are connected such that the 7040 functions as the input/output and control processor for the configuration and the 7044 is reserved exclusively for problem execution. The Bellcomm Monitoring System (BCMSYS) is currently installed and operating. As the system was only recently installed, some work which has not been converted from the previous operating system (IBSYS) is still being done in that system.

The Applications Programming Staff members are presently assisting various Bellcomm groups in the following programming areas:

(1) Patched Conic

To generate ascent and descent trajectories by the patched conic technique.

(2) Landing Dynamics

To provide consulting services in support of the Landing Dynamics Studies sub-contract.

(3) Navigation and Midcourse Error Analysis

To do error analysis of the navigation and guidance system, utilizing a Patched Conic program.

(4) Document Retrieval System

To automate the indexing of classified documents.

(5) Orbit Determination

To study orbit determination aided by optical sightings on lunar landmarks.

(6) PERT Capability

a. To convert and debug NASA (Lewis and Goddard) 7090 Fortran IV PERT program to 7040/44.

b. To supply NASA (MSF) with PERT processing support.

(7) Strapped Down Guidance System Feasibility Study

To study the feasibility of using a strapped down guidance system during lunar ascent or for abort in descent.

(8) Digital Differential Analysis

To generate a direction cosine matrix for an associated time interval for either a ternary or binary torque.

(9) Orbit Sensitivities

To calculate errors at given angles in a parabolic, elliptical, hyperbolic or circular orbit given errors in initial position and velocity.

(10) Lunar Ascent Guidance

To derive and check through computer simulation a set of guidance equations which are suitable for guiding the LEM from the surface of the moon to a specified circular parking orbit.

(11) Orbital Elements of Photographic Meteors

To generate a data file on computer tape for use in determining statistical data.

(12) Certification of General Use Subroutines

To provide programming assistance in the writing and testing of general use numerical solution subroutines.

(13) Spacecraft Module Sizing

To modify spacecraft Module Sizing computer programs.

(14) Apollo Reliability Simulation

To assist with Bellcomm's Apollo Reliability Simulation program.

(15) Communications Tracking Coverage Study

To compute and display tracking information from a spacecraft to a communications site.

(16) Micro-Film Plotting

To convert and debug Micro-Film plotting programs from 7090 to 7040/44.

(17) Program Conversions

To convert for 7040/44, certain Bell Telephone Laboratories programs that generate orbital elements of spacecraft and site visibility for communications and tracking.

The following is a list of study areas for which programs were written and were completed during this quarter:

(1) Error Analysis of a Strapped Down Guidance System for the LEM

(2) Radiation Shielding and Dose Calculations

(3) Statistical Variations in Flight Test Program Times

(4) Lunar Landing Sites 2,

(5) Minimum Fuel Thrust

ADMINISTRATIVE

Significant developments of the past quarter contributing to Bellcomm's technical capability or pertaining to contract performance are noted below.

Personnel

As of March 31, 1964 the Bellcomm staff included 155 members in technical occupations and 93 administrative employees.

During this quarter a cost effectiveness study was undertaken on Bellcomm's program of advertising for professional technical people. A revised program was adopted on a trial basis which will reflect considerable savings during the balance of the year.

Contract and Financial

In January the company's books of account were closed for calendar year 1963. The accounting firm of Lybrand, Ross Bros. and Montgomery audited and approved statements of financial results for the year.

On March 16, 1964 a subcontract was entered into with the Bendix Corporation for studies of lunar landing dynamics.

March 21, 1964 was the second anniversary of the formation of the company.